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Geographic Information Systems and Image Processing, Tools for Recreational Land Use Planning and Conflict Mitigation: A Case Study Within the Monument Open Space, Monument Colorado

Thesis directed by Professor John Harner

Several methodologies have been developed to determine the best utilization of land for recreational pursuit. Each has its benefits and limitations depending upon the incredibly complex factors and issues that surround recreation areas. One disadvantage of each of these methodologies is the noticeable lack of inclusion of geographic technology available. It is believed that Geographic Information Systems (GIS) and Image Processing programs used in conjunction with any of the planning methodologies can improve the planning process by allowing planners to spatially analyze and evaluate different management prescriptions.

Ten miles north of Colorado Springs is the small community of Monument. Just to the west of this community is an open space of approximately 1,000 acres. Designated as the Monument Open Space, it serves as a focal point of non-motorized multi-use recreation for the surrounding community. This space is managed by the United States Forest Service, which is currently working on adjusting its land management policy along the Front Range of Colorado.

This work demonstrates how geographic technologies can be used to improve existing recreation land planning methodologies through a case study using the Monument Open Space. It also addresses mitigation of conflict between user groups

during the planning process rather than at implementation. It is hoped that the US Forest Service recreation planners can apply these technologies and techniques along the entire Front Range of Colorado.

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by

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B.A.. University of Minnesota, Duluth, 1993

M.S. University of Nevada, Las Vegas, 2003

A thesis submitted to the Graduate Faculty of the

University of Colorado at Colorado Springs

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This thesis for the Master of Arts degree by

Troy Alan Carlson

has been approved for the

Department of Geography and Environmental Studies

by

John Harner, Chair

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Date

I would like to acknowledge several people who have inspired me to write this thesis. First, to my wife whose patience and understanding has no limits. To the Geography Department at UCCS who opened the world of Geography to me through lecture, lab and discussion. Finally, I would like to thank the United States Air Force Academy for which none of this would have been possible.

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CHAPTER I

INTRODUCTION

Several recent studies have noted that participation in outdoor recreation has been increasing (Cole 1996; Lynn and Brown, 2003; Wing and Shelby, 1999). However, the same studies note the availability of land for these recreational pursuits is declining and showing signs of wear and tear. While recreation planners have been active to try to manage the situation, their efforts have sometimes caused greater problems due to conflicts created between the users and resource itself. Neither the planners nor their methodologies are completely at fault; user expectation, user concentration and faulty planning efforts bear responsibility too.

Three changes incorporated into current planning methodologies have the potential to slow or reverse this trend on the resources while placing few restrictions on the various users. The first change is to incorporate geographic technologies such as Geographic Information Systems (GIS) and Image Processing (IP) into recreation planning methodologies. This effort will add spatial analysis capabilities that current methods do not have. The second change uses the geographic technology to explain problems and issues to the various user groups to solicit their inputs and present how planners achieve their solutions. The final change is to expand recreation planning efforts into a regional focus with local action. In this way, the burden of use can be

spread over a wider geographic area, supporting more users, enhancing user experience, and perhaps allowing even a wider variety of activities.

Along the Front Range of Colorado between Denver and Colorado Springs, much of the land is owned and managed by the United States Forest Service. Recreation Planners at the Forest Service are facing the same problems noted above. Denver and Colorado Springs are large growing communities. In the past, the Forest Service has allowed recreation pursuits to go relatively unregulated while they focus on other aspects of their organizational multi-use charter. That is currently changing; the Forest Service is now developing plans to take a more direct management approach to their Front Range holdings (Landis 2004). While the Forest service is looking at the whole Front Range, plan implementation needs to occur at the local level.

Regional planning and local implementation will be a key feature of future planning efforts. Before looking at regional solutions, we must first evaluate the extent that GIS and IP can facilitate planning. Along the Front Range, there is an excellent area to conduct a case study to evaluate the ideas presented. A little more than a mile west of Monument Colorado lies an open space of about 1,000 acres. Monument Open Space has served as a focal point for outdoor recreation for local residents and the surrounding area. Initial steps in changing the management prescription for the Monument Open Space were outlined in an implementation plan (Landis 1997). This plan lists some ideas and concerns that need to be evaluated before executing a final plan. A few items include reducing the number and extent of social trails, establishing a limited number of designated campsites and defining vehicle parking areas. By using this open space as a case study, it is believed that the Forest Service can leverage the results into the

beginnings of a regional plan for the Front Range, ultimately fostering other local recreation centers to execute plans that complement regional objectives with minimal conflict between user groups.

CHAPTER II

OBJECTIVES

The objective of this work is to demonstrate that greater incorporation of Geographic Information Systems (GIS) and Image Processing (IP) technologies can improve recreational land management planning and policy decisions, and foster and improve public understanding of those decisions. This will result in less conflict between all parties involved.

Specifically, this thesis will:

1. Highlight shortfalls in current planning methodologies that can be covered through GIS and IP methods.
2. Demonstrate that spatial analysis can be easily added to current recreation planning methodologies and be effective in advancing the planning process.
3. Show that GIS and IP technologies can be used to present planning considerations to stakeholders in a way that increases their understanding of any change and to solicit their input throughout in the planning process
4. Advocate, from this case study, expanding GIS and IP integration into planning efforts along the Front Range on both local and regional scales

CHAPTER III

LITERATURE REVIEW

In the late 1800's, Frederic Law Olmstead set out to provide everyone access to public open space. Open space became important in the later part of the nineteenth century in an attempt to relieve the "evils" of urbanization (Garvin, 2000). Today open space is increasingly important and valuable; there have been substantial increases in recreational use of natural areas in recent decades (Cole, 1996; Lynn and Brown, 2003; Wing and Shelby, 1999). Lynn and Brown indicate a tenfold increase in wilderness recreation over the past 40 years, with the fastest growing recreational activities connected to trail use. Researchers found that an estimated 94.5 percent of the population reported participating in outdoor recreation at least once in the last 12 months (Ewert, 1999). With this increase in usage, developing open space should not be viewed in terms of singular use. It should be planned and developed with an emphasis on multiple-use (Garvin, 2000).

Use may vary from place to place and the general trend towards slow and steady increases in use are the norm (Cole, 1996). Other trends are stable visitor evaluations of wilderness conditions over time and increases in support for trail maintenance and installed control measures. Overall, trail systems are holding up, but in sensitive areas, the impacts are severe. The same can be said for campsites.

Cole (1996) concludes that management efforts are usually reactive rather than proactive, let alone interactive. Even the most favored management tools, indirect management and use limits, have become so institutionalized that they paralyze managers from selecting and implementing other courses of action. According to Cole, this is wrong; managers must attack problems early and aggressively in order to mitigate the problem as quick as possible (Cole, 1996).

In order to look at how geographic technologies can be incorporated into the planning process it is important to establish the context in which geographic technology should be inserted. The first portion of this literature review will look at the value of planning and management and the importance of having a strategic view of all factors that influence recreation. The next section looks at some current planning methods. The third section discusses conflict that occurs between user groups. I discuss methods used to turn conflict into a source of positive momentum to successfully restore a recreational landscape without alienating any particular user group. The final section discusses what geographic technology is available and highlights its value in a few applications. Each section builds upon the theme of improving the planning process with geographic technologies to plan for and provide recreational opportunities and at the same time reduce conflict at several levels.

Value of Planning and Management

A majority of research on recreation benefits has focused on outcome or goal oriented behavior and behavior that influences recreation choices (Daigle et al. 2002). One such behavior is sensation seeking, or the active pursuit of an adrenaline rush.

Daigle and others found that certain recreational activities are better suited to certain people, for example not everyone wants to rock climb nor does everyone want to be a birdwatcher. Daigle and others incorporated the influence of the location in their research to evaluate the extent that location plays on recreation benefit. They found that perceived benefits are tied to the benefits derived. Otherwise stated, the individual engaged in a recreational pursuit gains from both activity and the particular location, supporting the authors' theory that location has relevance to recreation benefits research. Overall, their findings show that land management decisions should maximize the possibility of the user to achieve their perceived and derived benefits relating to location.

Managers and planners of recreation resources have a difficult task of balancing a growing number of users and activities on a shrinking resource (Wing and Shelby, 1999). This increased pressure on our natural resources also has the effect of making management decisions more difficult, complex, and contested. McCool and Cole (2001) highlight that planning efforts implemented on a local scale without regional impact assessments have resulted in management decisions that do not optimize recreation opportunities, and in effect defer problems from one area to another. In fact, they state that managers and the public have been victimized by a "tyranny of small decisions" (McCool and Cole, 2001, p. 89). Each decision represents a tradeoff for any given setting, but in sum does not maximize the benefits of a system. It is their belief that wilderness and backcountry areas exist not on a site-by-site basis but within the context of a region where such areas constitute a system. Management actions in one area influence use patterns, biophysical, social conditions, and eventually actions in others (McCool and Cole, 2001).

A finding of even more concern over a regional view comes from conservation biology research. According to Crumpacker (1998), compelling biological evidence shows that failing to consider some sort of large-scale ecosystem management in the natural and semi-natural areas of the United States will result in the loss of natural biodiversity. Ewert (1999) supports this position, he states that current rates of use and destruction are unsustainable and future use will most likely continue to exceed carrying capacity. Advancing technologies are increasing the reach people have into previously unmolested natural areas. Once in the remote areas, some individuals' general lack of ethical behavior compounds the problem. Ewert offers three approaches to correcting this problem: visitor management, site management, and information management. All three, benefit from planning efforts.

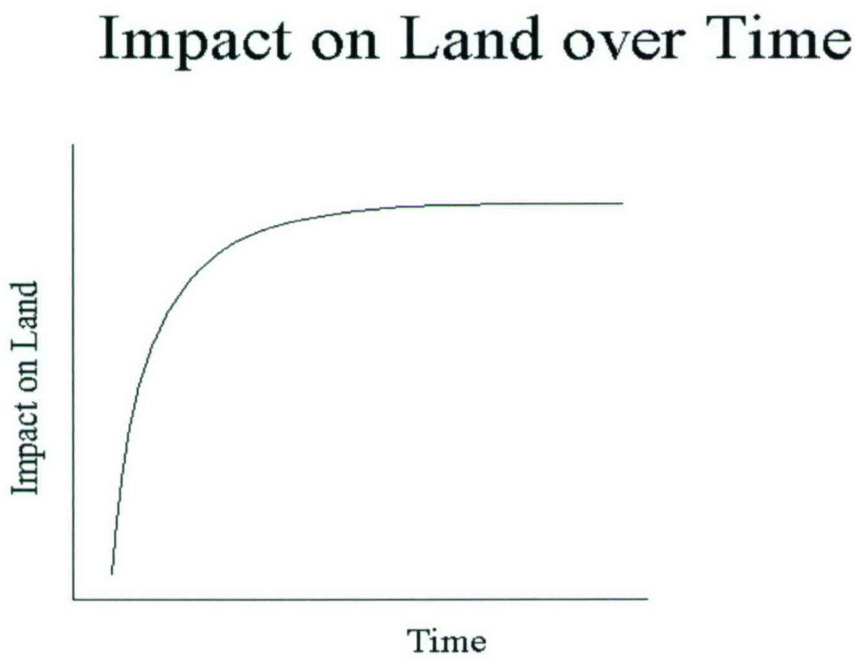

Figure 1. Impact on land in relation to time (Adapted from Cole 1994, and Ewert 1999)

With the absence of planning, management and protective actions, the impacts of heavy use can become severe and widespread over a short period of time (Cole 1994; Ewert, 1999) (Figure 1.). Cole looked at research in wilderness areas and notes that frequency and concentration of use result in the greatest impact. Cole also states that controlling impacts can be achieved by limiting use in low frequency areas, limiting repeat use of an area, and dispersing use in a low frequency area. Other factors, such as type of use, season, and environment also have significant contribution to the overall impact and should not be forgotten (Figure 2).

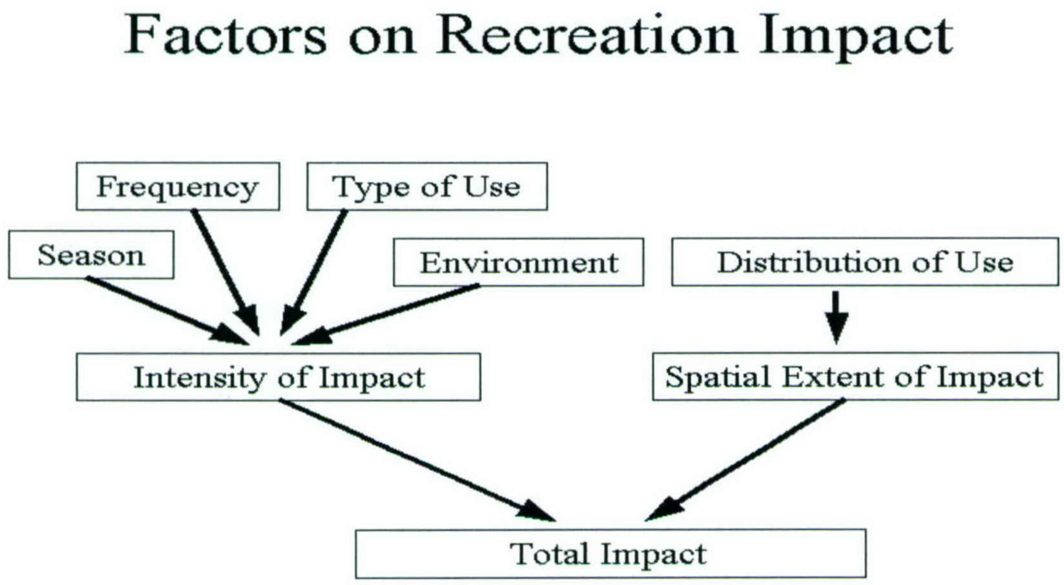

Figure 2. Factors of recreation impact (Adapted from Cole 1994)

Recreation in natural areas can have significant effects on the geomorphic and hydrologic processes that are disproportionate to the surrounding undisturbed area. Therefore, quantifying the impacts of recreational land use has become a necessity for the scientific management of natural areas (Southerland et al., 2001). Southerland and others

found that soil compaction on trails reduced water absorbency and that the shearing action of foot traffic also causes excessive vegetation wear, further reducing water absorbency, especially on steep slopes. Although trails make up a small portion of land within a drainage area, they contribute to a disproportionate amount of total impact (Southerland et al., 2001). Because of this, planning is critical to prevent unwanted wear on the environment, and presents an exceptionally good application for geographic technology.

Research on the best restoration methods in a given area is also important. Recreational land use planning must include restoration work in order to maintain the natural environment and positive user experiences. Restoration usually involves closing access to areas that are slow to recover. Zabinski et al. (2002) looked at ways to speed up restoration time and found that augmenting impacted areas with compost to increase organic materials can reduce recovery times, plus new or regenerative growth was twice as abundant in augmented areas than areas without augmentation.

Past and present research leaves an impression that recreation in natural areas is damaging and that damage must be monitored and restored in a timely manner. Leung and Marion (1999) discuss the value of monitoring trail use to avoid excessive wear over a wide area. They also note that trails in protected areas are not a negative element because they provide access and recreation opportunities while protecting the resource by concentrating the traffic along a narrow corridor. Trail impact assessment and monitoring is thereby very important because trails, if left unchecked, can deteriorate and indirectly cause problems. Trail monitoring can be an easy addition to current planning and management methodologies. Leung and Marion (1999) found that other studies

examined impact monitoring, yet few agencies have implemented an active program. Leung and Marion assessed four aspects: trail incision, wetness, root exposure, and multiple trails. Although their findings show good levels of accuracy and application for land managers, they did note a few problem areas within the research framework. Uniform data collection between users and data collection intervals were their greatest problems (Leung and Marion, 1999). Despite the problems, their work could be valuable at targeting problem areas and focusing corrective actions. This is important because the authors note that park crews and volunteers do trail work on a limited basis due to budget cutbacks.

Recreational land planning is very complex and requires constant attention in order to maintain a balance between resource preservation, access, and reducing impact based on use patterns. Available planning methods, though fundamentally similar to each other, have different strengths and weaknesses depending on the context and parameters. Choosing the correct method reinforces the importance of understanding the resource users and potential impacts over a long period.

Planning Methods

Perhaps the most important planning aspect incorporates the needs of the people who will use the recreational space (Carr and Williams, 1993; Lebeerman and Mason, 2002; Lynn and Brown, 2003). A key element of providing effective recreation land use planning is to know the values of the stakeholders, community and interested parties (Lebeerman and Mason, 2002; Carr and Williams, 1993; Godbey et al., 1992). Carr and Williams (1993) elaborate that different cultures use open space in different ways even if

they are of similar ethnicity. Further support comes from a nation-wide research project that found that the strongest perceived benefit of parks belonged not to an individual or family but to the community. Even 71 percent of park non-users identified the community as the recipient of the largest benefit (Godbey et al., 1992). In a case study, Lebeerman and Mason (2002) found that by communicating directly with the users either by mail surveys or by direct contact, better land use decisions could be made and implemented.

One stage in planning and developing recreational land is conducting a benefits analysis. Siderelis and More (1995) found that rail-trail users valued rural areas more than suburban areas. Specifically, those users would travel farther and spend more time on rural trails than urban trails. The researchers were able to calculate a monetary benefit for the trail. Although this is an after the fact analysis, it could be used to determine the value of future development of the land.

Planners must also consider one of the more interesting aspects of good land use planning: the potential for increased revenue based on increased property taxes of adjacent property. Crompton (2001) notes that an increase of 20 percent in property value along a passive park is reasonable. This can result in generating revenue rather than becoming a non-recoverable expense. This revenue could cover maintenance and sustainment costs.

Along with initial planning, long term planning should also be a part of the process. The concept of sustainability has been a topic for several years. Sustainability within the scope of land use planning and outdoor recreation is critical because increased use without adequate efforts to maintain natural and cultural integrity adversely influence

the experience quality of the user (Lawson et al., 2003; Lynn and Brown, 2003). In fact, respondents to the Lynn and Brown study indicate that naturalness was the greatest contributor to their overall experience.

One valuable resource, Flink et al. (2001), outlines a planning procedure that takes into account several of the concepts mentioned so far and provides detailed illustrations that show ideal trail surface composition, width, and minimum heights for obstructions such as tree limbs. Illustrations also show ideal curves in trails depending on use and how to plan for natural barriers for privacy. While their designs and illustrations work well for developed spaces, their application in the Monument Open Space would be impractical because they would not preserve the naturalness desired by users because Flink's trail suggestions are generally wide and well manicured. Flink et al. (2001) highlight several planning and design considerations such as use variety, trail surface material, width, density, and privacy so any planner can ensure that they do not forget an important element.

One planning method available is the focal-species approach, although it is controversial in use and application (Lindenmayer et al., 2002). The focal-species approach is based on the notion that selecting the most demanding species in an area and making decisions based upon that species will have an overall net effect of also benefiting other species. The authors acknowledge that there is a need for landscape restoration to conserve biodiversity. However, they disagree with restoration efforts based on a single species or narrow group of species. The basis of this disagreement is that the authors fear potential social and cultural bias towards a popular species such as a large carnivore. Popular species may not be the most demanding species, and if selected

as the base for restoration efforts, the results may not be as successful as possible. They also have concerns about how this restoration effort assumes that other species are nested within the parameters of the focal species. Given these concerns, the authors advocate that a conservation tool include the social, economic and political realities of the area. Once these cultural aspects are introduced and understood, Lindenmayer et al. (2002) suggest that a wide range of strategies that incorporate cultural aspects be developed and used in landscape restoration. The authors believe that it is risky to use a single focal point in such a complex problem needing urgent solutions and that implementing several remedies at once will have a higher overall success rate.

Within the past 20 years, the United States Forest Service has made considerable advancements in its recreation planning methodology. What was once devoid of public involvement and narrowly focused now actively seeks public comment, applies the best scientific knowledge, including basic GIS technology, and approaches decisions based upon the whole ecosystem, which also includes human impact factors. This method is known as the Values Suitability Analysis (VSA) (Reed and Brown, 2003) (Figure 3).

The base for Values Suitability Analysis came from the environmental classic Sand County Almanac written in 1949 by Aldo Leopold. In this text, Leopold looked at the earths resources as a system in balance. However, human interaction in this system has disturbed this balance, so he eloquently outlines a different view of resource management, one that considers the entire ecosystem.

Reed and Brown (2003) used this VSA methodology in a case study and admired its ability to capture data and compare various combinations and relationships. However, they also found that the method was still a little too experimental in that they and other

resource management professionals were reluctant to accept the judgment of the general public to resolve management issues. Reed and Brown (2003) speculate that with use, this reluctance will subside, so the VSA can develop as a useful and valuable tool for the resource managers and stakeholders.

Values Suitability Analysis (VSA) Process

1. **Identify Management Area(s)**
2. **Inventory Ecosystem**
3. **Inventory Range of Activity**
4. **Assess Activity-vs-Value**
5. **Identify Management Prescriptions and Allowed Activities**
6. **Mix Management Activities and Prescriptions**
7. **Determine Ecosystem/Prescription Compatibility**
8. **Evaluate Ecosystem/Prescription Compatibility with Management Area(s)**
9. **Assess Management Alternatives with Management Area(s)**
10. **Perform Sensitivity Analysis**

Figure 3. Steps in VSA process (adapted from Reed and Brown 2003).

Another planning method is Limits of Acceptable Change (LAC). Krumpe and McCool (1997) describe the method as a rational, science-based planning process. It is primarily concerned with resolving the conflict between the goal of preservation and access. Before using the LAC model, planning efforts did include public participation, but that participation had become adversarial. Perhaps this occurred because the participation phase often became a point of conflict between users, planners and the proposed actions. In essence, the public spoke but they were not a part of the planning

process. Krumpe and McCool (1997) even state that previously the public was viewed as unqualified to engage in planning because of a lack of technical competency to proceed or contribute in a constructive way.

With the first use of LAC, that adversarial relationship began to diminish. The focus was to create a consensus rather than seek consensus. To do this the LAC makes efforts to establish dialogue between user groups so they can learn about each others' interest, and then foster deliberation on a controversial topic so informed decisions can be made, facilitating the creation of consensus (Figure 4.). Early inclusion and active involvement of the public based upon open dialogue and including a variety of user groups can assist land managers and obtain resolution to issues faster (Krumpe and McCool 1997).

Limits of Acceptable Change (LAC) Process

1. Identify area concerns and issues
2. Define and describe recreation opportunity groups
3. Select indicators of resource and social condition
4. Inventory resource and social conditions
5. Specify standards for resource and social conditions for each group
6. Identify alternative opportunity groups
7. Identify management actions for each alternative
8. Evaluate and select preferred alternatives
9. Implement actions and monitor conditions

Figure 4. Limit of acceptable change process (Adapted from Nilsen and Tayler 1997)

In a related article, (Krwnpe and McCoy 1995) discusses various methods for fostering the consensus strived for in the LAC. They advocate creating a task force that represents the various user groups and then empowering them to define responsibilities and procedures to accomplish the task. Perhaps the most interesting aspect of this was when Krwnpe broke the task force into groups and had each group begin to develop one aspect of a management plan. He then rotated the groups before they completed their plan to work on another group's plan without making any changes to previous work. Then once every group has worked on each plan, the original group would write a plan that incorporates suggestions from the other groups. This method takes time but it incorporates a high degree of input and facilitates understanding.

The overall complexity of planning is almost overwhelming, given all the different considerations. It is a good thing that some methodologies exist to guide planners so key elements are not overlooked. Adding geographic technologies to these methods could be viewed as complicating the issue. However, the converse is true. By incorporating GIS and IP products, a clearer picture containing several planning considerations can be created, presented, and discussed early in the planning process, which in the long run will make planning efforts easier.

Unfortunately, even with the best data and maps there is still going to be an element of conflict between the resource and users, between user groups, and frequently between land managers and users. By using the geographic technologies discussed early in the planning process, these conflicts can be mitigated because stakeholders can see problem areas and discuss solutions that accommodate everyone.

Conflict

Green (1992) states that litigation is perhaps the greatest manifestation of conflict and is being used more and more to settle disputes concerning land use. Conflict between user groups and the natural environment are inevitable when crowding takes place. Several land use and recreation researchers have examined or acknowledged the increasing amount of conflict. For instance, Bell (2000) looked at the conflicts created when a speed limit was considered on boaters using a lake. These limits affected not only the speed boaters but all associated activities with fast moving watercraft as well. Bell Found that the level of conflict and the associated policy response varied depending on the interests of those involved. He also found that some individuals may have their preferred recreation method denied because they are not in as good of position to advocated their desired outcome to policy makers as well as the opposing group.

Conflicts may just boil down to simple difference in perception, when in reality the impact of the contested recreation is far less than what is perceived. Yet, perceptions are reinforced through irresponsible behavior. In the case of Bell's study, it was noted that irresponsible behavior was not the sole cause for the conflict it was that the number and variety of users were as a whole incompatible. Bell also states that when conservation and recreation conflict, the latter should take a second position. Ten years since this initial survey, a final solution has not been found, and litigation will continue for this particular location.

Conflict between users occurs at both the individual and group level. Perhaps the best framework for discussing conflict between users is with the goal interference model (Ivy et al., 1992). Goal interference is defined as an individual experiencing conflict as a result of a behavior or action by another individual to the extent that the users take efforts to avoid each other. Additionally, there can be disproportionate conflict between users; for instance, human powered recreational pursuits have a greater level of conflict with motorized pursuits than vice versa.

Within this model there is a variable consisting of individual tolerance. Some users have a near total intolerance while others may be willing to accept the other user. Taken even further there is also an acceptable range of deviation from accepted norms within a particular activity. For example, hikers generally tolerate other hikers on a trail even if they are making a bit more noise than preferred. However, cutting across switchbacks or deliberately walking off trail is not tolerated. Compounding this problem is that tolerance is not applied between individuals, it is applied with a wide brush that places individuals within the whole context of the opposing view. Ivy et al. (1992). found that proximity was key for conflict to occur and that conflict was not balanced. There was a disproportionate amount of conflict from one group to another. User expectation and level of tolerance played key roles in the experience. They also recognized that spatial separation would work well in managing the conflict, but suggested that users establish reasonable expectations that match available opportunities so that intolerance is not excessive.

Another type of conflict surfaces when user groups move to different areas. Cole (1994) states that there is little to be gained by limiting use in heavy use areas because

directed use restrictions will only serve to displace those users into another area, thereby increasing use at a different location. This displacement has a net effect of just moving the same conflict to a different location, resulting in two heavily impacted areas. This is another result of non-regional planning. However, Cole does say that limiting use in low use areas or encouraging the dispersal of use could result in better recovery rates due to the reduction in use pressure.

Usually conflict is described as a negative aspect. However, there is hope that it can be used to create synergy and result in a positive change for land management decisions. Case in point is the restoration undertaken in a waterfront park in Chicago. Gobster (2001) looked at an urban park that supported a wide variety of recreation and leisure pursuits. During his investigation, he discovered that this park was also seen as a place with strong emotional connections for the various users. This added new dimensions in considering a course of action for restoring the park.

Four different perspectives of the landscape were looked at designed nature, habitat, recreation and original status. Gobster worked with various interest groups to recount the historical development of the park and current status. He then worked with the various interest groups to achieve a consensus. He noted that the users were very much engaged in the process when their area of interest was discussed and then became detached when other aspects were being worked out.

In the end, it was determined that there could be several variations on the landscape but the successful restoration of this park came from channeling the conflict and creating a consensus that integrated the different visions of the park's stakeholders (Gobster 2001).

From creating simple products to complex models, geographic technologies incorporated into planning efforts can simplify the planning method. As discussed this simplification can reduce conflict and facilitate understanding. This is truly a case where a picture is worth a thousand words. With early programs creating these pictures was not easy, however, software packages and the availability of data has made the use of geographic technologies easier and readily available as this final section points out.

Geographic Technologies

Green (1992) states that as a result of our population growth and associated use of land and change in land cover, land managers are finding that their land use decisions are being played out in the court system. This trend has created the need to incorporate GIS into land use planning because of its ability to analyze and prioritize land management alternatives.

The need for GIS data has also sparked an equally strong need for digital imagery. Five advances (Green 1992) have facilitated this revolution in data management: 1. improved imagery, 2. computer processing, 3. software integration, 4. accuracy in production, and 5. software training. With this technology, it is easier perform spatial analysis and other functions vital to recreation land planning. Additionally, planners can produce large maps to be used in public meetings, opening up a completely new level of understanding. Green (1992) concludes that the conflict over land management will not end, but GIS and digital imagery will continue to be a valuable resource for managers needing affordable, accurate and fast data concerning their landscapes.

Simply knowing for whom and what to plan and then incorporating sustainability and restoration efforts to maintain an area is not enough. GIS needs to be used to facilitate land use planning in several aspects. According to Nicholls (2003), GIS can be used to determine accessibility of parks and open space with the surrounding population. To demonstrate this, Nicholls conducted a spatial analysis of park accessibility in College Station, Texas. She used a predetermined accessibility parameter of walking distance of one half mile or less measured from the edge of the park boundary. This parameter created a GIS buffer from which Nicholls was able to determine the total area serviced by the parks. This information can then be used to determine areas in need of additional parks. Nicholls also points out that further research and analysis could also determine specific service distribution of parks to best serve adjacent demographic and socioeconomic groups.

Other research using GIS can be used to analyze the potential of an area to support recreation behaviors of a specific group (Kliskey, 2000). Through developing a similar process as that used to model forestry and wildlife research Kliskey focused on recreation suitability. Kliskey (2000) determined the suitability of a particular area using the desires of a recreation specific group. This analysis can then be used alone or with other GIS models to determine the extent of overlap and interaction between various parameters. Management decisions for multi-use areas can be made without significant negative impact on any one interest area or group because managers can focus on overlapping areas to reduce conflicts.

Not only can GIS be used to conduct spatial analysis for the provision of service for existing facilities and development potential on the behalf of specialized groups, GIS

can be used to determine positive and negative perceptions of satisfaction based upon proximity to the resource. Tarrant and Cordell (1999) studied the spatial relationship of recreation sites with census block groups to determine if socio-economic inequities could be identified. Their results were not definitive and the study had several limitations, but their application of GIS, evaluating population, distance, and experience quality, can prove valuable to land managers, especially in the realm of resource preservation and benefits analysis. In another study GIS was used to determine the usage demand placed upon woodland recreation sites in England based upon travel time (Bateman et al., 1999). Although this study did not account for specific or unique attributes of the destinations, which could be a significant factor in destination choice and usage, it does provide planners with a predicative model of usage.

Bryan (2003) states that land use conflict exists in both developing and developed countries. Therefore, planners need to make landuse decisions based upon accurate spatial information. Previous classifications lacked adaptability when applied to complex landscapes. GIS can be used to provide more detail due to its access to data and ability to model, analyze and provide visual results faster. Planners can now make decisions faster, and more accurately than before as a result.

The physical environment holds the key to suitability of land use choices. The scale needed to effectively research the landscape needs to be large enough to show biological variety as well as variation in physical aspects such as rainfall and temperature (Bryan 2003). The results from Bryan's work show that even using limited amounts of GIS data, land planners can model the physical characteristics of an area to determine suitability for particular land uses. Once models are created, only the flexibility of the

user limits analysis and comparison. Bryan's work reinforces that GIS can be an effective tool in filling knowledge gaps relating to spatial distribution, thus adding to the base of geospatial data.

One current issue in planning processes is that there have been several models developed to facilitate landscape restoration. These models are limited in that they focus on small scale areas or focus on a particular problem. This is in part because restoration efforts are expensive both in dollars and human efforts (Holl et al., 2003). The authors call on managers and scientists to plan and model their efforts better in order to collect the most effective data possible. One method to do this is to include GIS and IP technology because of the modeling capability over spatial scales are impossible to replicate in the field and their usefulness in simplifying prioritization and coordination of restoration efforts. Again, this reinforces the regional need for planning and implementation at the local level.

There is significant value in incorporating geographic technologies into recreational land use planning. These technologies can help planners identify, inventory, and track resource status and usage. This data can simplify planning methodology by compressing many individual data sources into a single easily interpreted product, such as a usage density map. This product can be manipulated with a few keystrokes to predict a possible outcome given a particular management prescription. Likewise, the inventory and modeling capability can be used to work through and resolve conflicts between user groups because they will be able to see the impact and results of changes nearly immediately and then make adjustments until a consensus is created.

CHAPTER IV

MONUMENT OPEN SPACE

History

The area currently known as the Monument Open Space (Figure 5) was originally operated as a Forest Service nursery from 1907 to 1965 (Landis 1997). The entire area was used to support nursery operations with no provision for public access or recreation. Throughout the area old foundations, irrigation ditches, and even remnant rows of plantings can be seen.

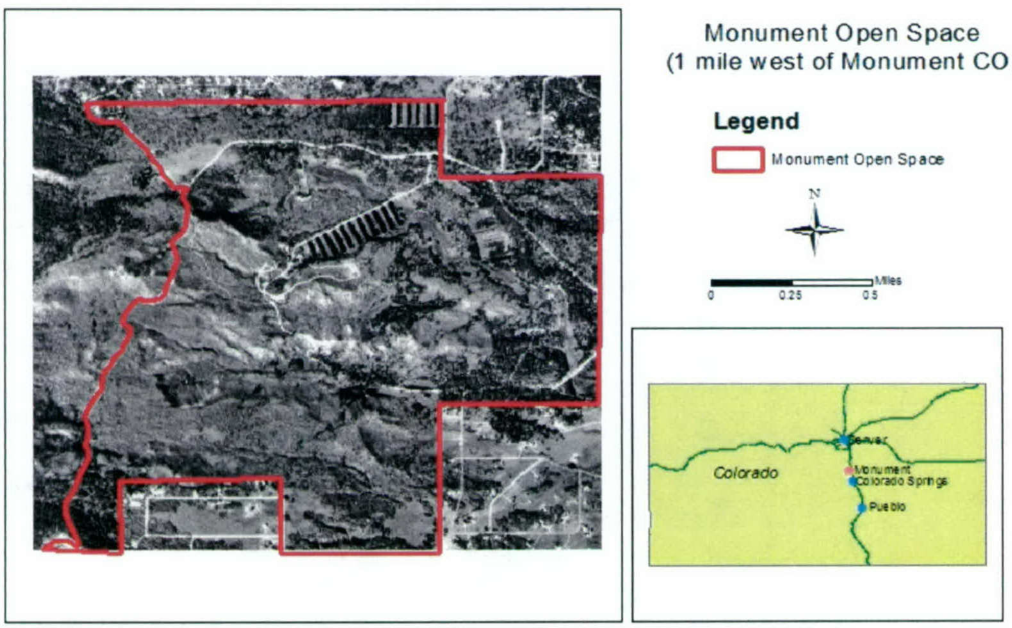

Figure 5. Monument Open Space

Once the nursery closed, the area began to develop recreational use. The Forest Service did not prevent access or offer any land management prescription. As a result, cattle grazed on the land to control vegetation. Beginning in 1979, an interagency hotshot fire crew took residence in the administrative area but did not perform any renovation or maintenance to the structures, which were in poor condition. At that time, the Forest Service had not created any management plan but became aware of the developing recreational use of the area.

The first recreation management action occurred in 1989 with a restriction of shooting firearms in the Monument Open Space, with the exception of licensed hunters pursuing game. The Berry Fire also occurred in 1989. While all the structures were saved, nearly all of the 1000 acres were burned. Thus, the area is still regenerating today. The Open Space remains today due to a Forest Service decision in 1994 that rejected a land exchange of several hundred acres. The exchange would have permitted additional private development around the fire center, but the lack of an agreement preserved the open space as a focal point for year round recreation with local residents.

Current Status

Within a 25 mile radius of the open space lives a population of over 600,000 people, and within one hours drive (50 miles) live an additional 2.5 million people (Landis 1997) (Figure 6). As of the writing of the Forest Service Implementation Plan in 1997, the Forest service has not directly managed the property for recreation, nor has it promoted its use for recreation.

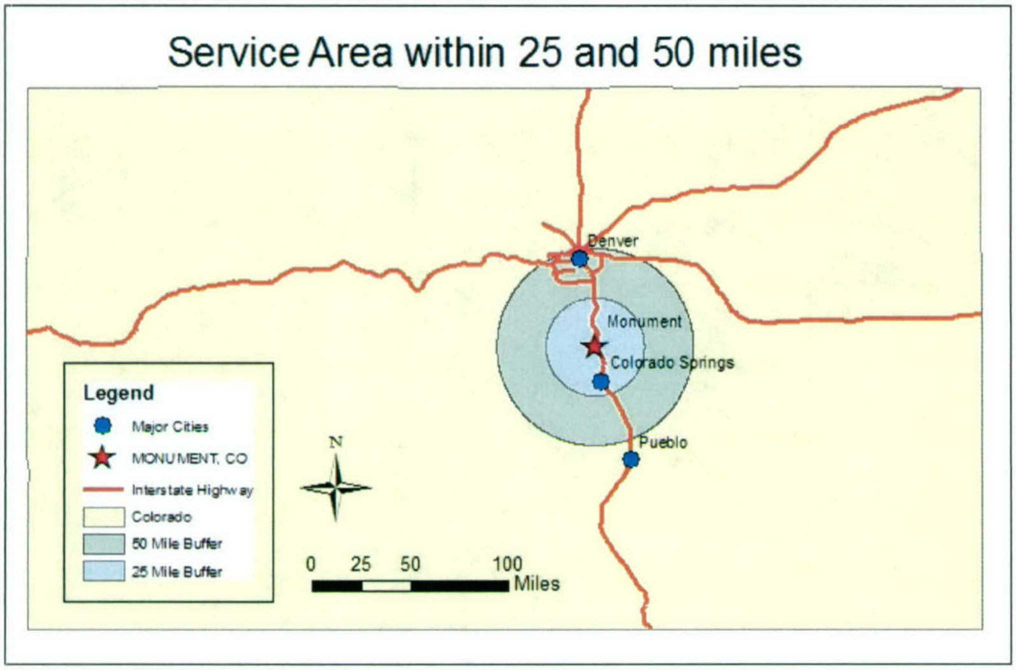

Figure 6. Service area within 25 and 50 miles

However, the Implementation Plan does outline some goals for recreation management in this area. The goals include (Landis 1997):

- Develop a systematic trail network of logical loops that also includes three trailhead locations with parking
- Develop two to three designated campsites north of Mount Herman Road
- Enhance wildlife resources
- Renovate and preserve historical structures
- Interpret cultural and natural history

While it is beyond the objectives of this thesis to develop plans to address the goals listed above, they can be used to serve as a foundation to illustrate the power and capability of geographic technologies.

Facilitating efforts to achieve the goals listed above is a group of volunteers, Friends of the Monument Preserve, that are working with the Forest Service to ensure that the open space is preserved and maintained in order to provide the best possible recreation experience. Organized about six years ago, the Fiends of the Monument Preserve plan and schedule monthly workdays to repair trail damage, pick up trash and debris, plant seedlings, renovate structures and control the spread of noxious weeds during the summer months. In the winter, they meet to discuss and coordinate administrative issues and plan the next summer's events.

In recent conversations with various members of the Friends of Monument, they have relayed that some of the trails are as old as the nursery and cattle grazing days. Their efforts have been to maintain those trails and improve on them by installing rain diversions and switchbacks where appropriate. It was also relayed that mountain bikers, hikers and equestrian groups use all the trails but, there is rarely a conflict between users because most everyone is courteous and polite. The main point of contention the volunteers noted is with the parking situation. On weekends, the small lot overflows and cars are parked along various portions of Mt. Herman Road.

CHAPTER V

METHODOLOGY

This thesis focuses on using maps and images manipulated in GIS and IP software packages and then incorporated into a planning method. The first step was to identify a planning method and determine where geographic technology could be incorporated. Using the Limits of Acceptable Change model as a guide, I determined that spatial analysis could be included at several points in the planning model. These points include:

1. Inventory existing resources and social conditions.
2. Specifying standards for resource and social conditions.
3. Identify management actions for each alternative.
4. Evaluate and select preferred alternatives.

Applied to the Monument Open Space, the first point would be to collect or create GIS feature layers that establish a baseline for what the current conditions are. These layers include: soil profile, trail locations, streams, roads, buildings, fire points, topographical data, etc. The GIS data used for this case study came from several sources. Most of the GIS data were collected from the Forest Service database. Other contributions include internet geography networks and data electronically stored within the UCCS Geography Department.

The second point has a great deal of subjectivity in it because the establishment of resource and social standards has to be from the consensus of the planners and

stakeholders. By using example standards applied to the base data already mentioned, this case study will be able to demonstrate the analytical capability of GIS.

Once standards are specified and applied in a GIS framework, planners and stakeholders can then focus efforts at resolving the issues at specific locations. This is the third application within the Limits of Acceptable Change model.

The last point is the culmination, where planners and stakeholders evaluate alternatives and decide on a course of action.

Using satellite imagery within the Limits of Acceptable Change model has similar applications as GIS. Satellite imagery can be used to support collecting current and accurate base data such as soil type and vegetation cover. Imagery can be used to help identify specific areas where resource standards are being impacted the most. Satellite imagery is limited in its ability for spatial analysis, however, it can be used effectively in longitudinal studies to track how well implemented management decisions are working by showing change when compared to original or ideal conditions.

Using these planning method steps, the next pages illustrate spatial analysis applications based upon conditions and goals outlined in the Monument Open Space Implementation Plan and the Limits of Acceptable Change planning methodology.

There was some variation in the trails layer not fitting with the underlying digital orthophoto, but not to the extent that it would cause problems since the variation was localized. This highlights the importance of having data layers that overlay each other properly in order to have accurate spatial analysis.

To show the limits of the open space, a feature class was created that outlined the open space boundary and a second that delineated the fire center administrative area.

These were created by using the map provided in the implementation plan (Landis 1997) cross-referenced with the digital orthophoto provided by the Forest Service. Once these features were created, I GIS tools were used to clip other feature classes based upon the boundary of the Monument Open Space in order to focus the analysis to the area within the open space.

Using ESRI ARCMAP 9.0, and the base data collected, several maps and images could be created and used in a presentation during a stakeholder meeting to plan the future of the Monument Open Space. These maps and analysis illustrate the goals of the plan.

The first map, Figure 7, outlines the existing trail network. In this map, the only road with public access is the red line that runs across the top and west side, known as Mt. Herman road. The central roads, although wide enough for vehicle traffic, are closed except for official use vehicles to conduct maintenance duties. Otherwise the roads are still available for non-motorized use. The trail network is dense, it is actually well above what the Forest Service considers allowable (Landis 2004). Currently the Forest Service only recognizes one trail and Mount Herman road, the classified routes.

One of the main issues within the open space is the total mileage of trails within the open space. The attribute table for Travel Routes revealed that there was nearly 24 miles of road and trail surface. Of this over 60 percent was comprised of social trails. Social trails are networks of roads and trials that have not been recognized or mapped by the Forest Service. In essence, they are illegal trails, and the Forest service would generally like to eliminate them.

Using an assumed recreation trail density of 10 miles of trail per square mile of land and with this open space approximately 1.5 square miles, there is an excess of nearly 10 miles of trail within the open space.

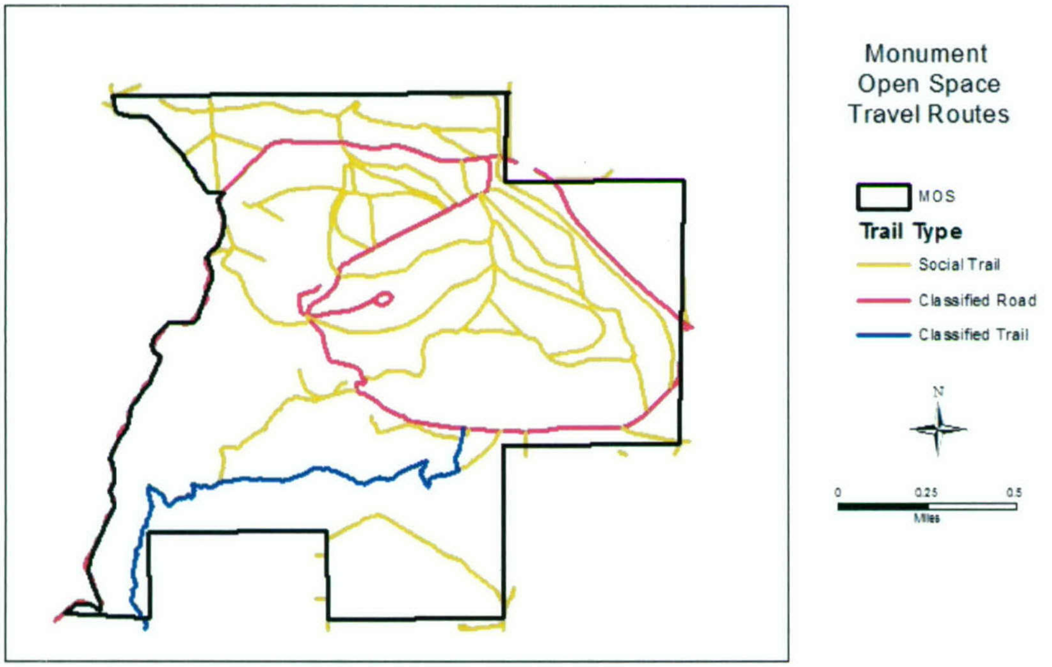

Figure 7. Monument Open Space roads and trails

One way to determine how to reduce the trail density is to look at trail proximity. Figure 8 shows areas where there is another trail within 50 meters. Trail proximity at intersections are obvious but in the north and northeast portions of the open space it is clear that the trails are very close together. These are candidate areas for trail elimination or consolidation.

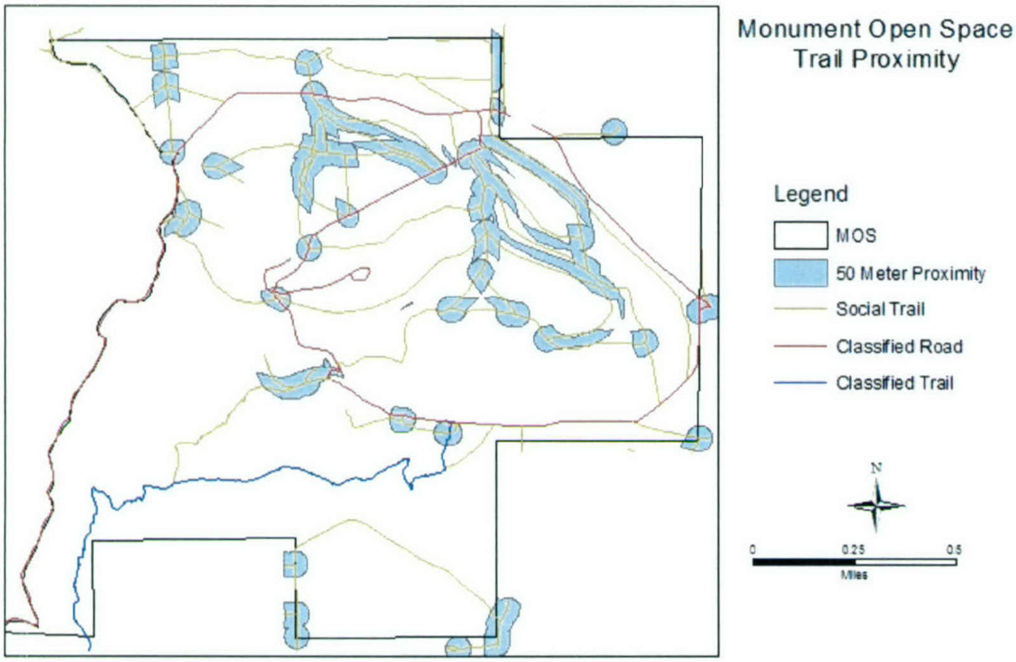

Figure. 8 Trail proximity

Another method to determine candidates for trail reduction might be to identify trails in sensitive ecological spaces, in this case where the travel routes cross streams.

A 5 meter buffer around streams was intersected with the travel route layer. The results show that there are several points at which the trails either cross or are within 5 meters of a stream (Figure 9). These show potentially damaging ecological impacts and should weigh in the analysis of trail elimination or consideration.

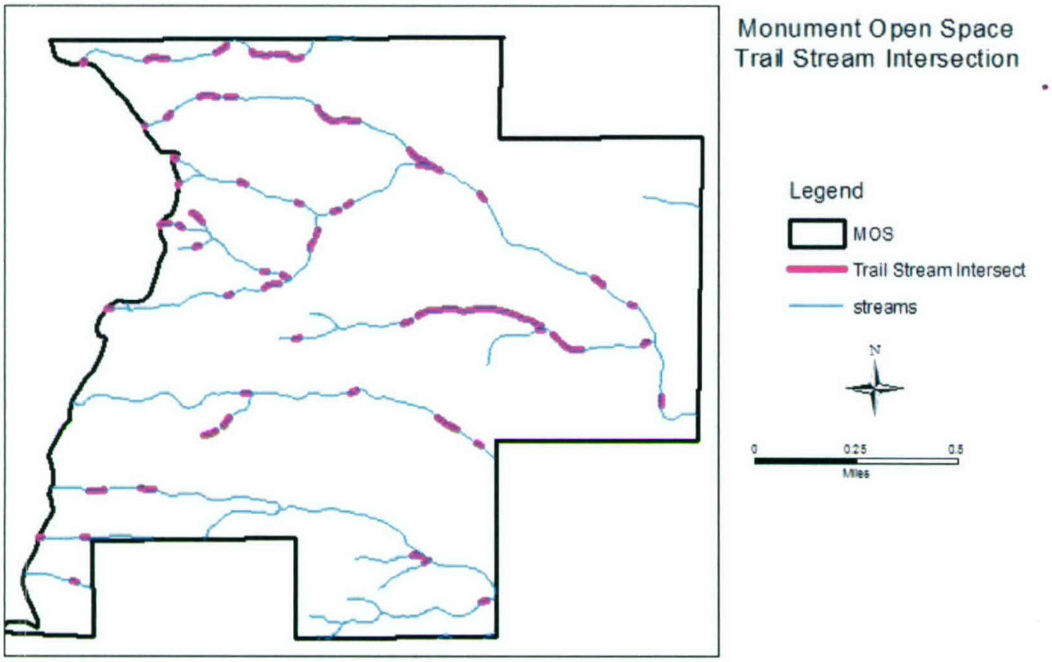

Figure. 9 Trail and stream intersection

Planners can use GIS to see how frequently trails intersect a particular soil profile in order to evaluate trail erosion and damage compared with other soil types. Figure 10 shows the soil series within the open space. Soil type and characteristics are important in planning because some soils are less resilient than other to impacts of recreational use, in this case, shoes, hoofs and tires. By evaluating the intersection of trails with the soil profile, planners and users can see exactly where wear and erosion problems are likely to occur.

Figure 11 illustrates the intersection of the Travel Routes with the Aquolls soil profile. The Aquolls profile was selected because of its close relationship to the streams and perceived higher erosive characteristics. When we combine the green trails in Figure 11 for the Aquolls soil with the trail

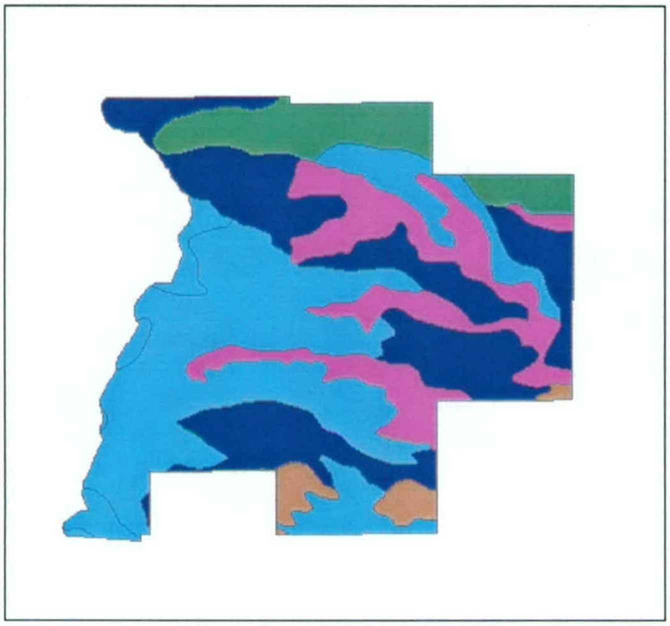

Figure. 10 Soil series

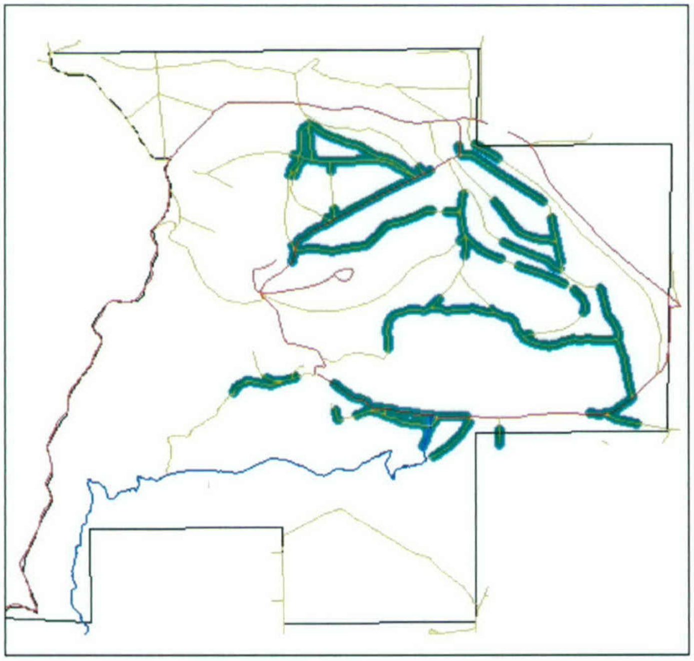

Figure. 11 Travel route and Aquolls soil intersection

and stream intersection we begin to generate new layers that create a model, showing trails that could be considered for removal. However, we can further refine the model using additional factors before removing trails. Until now there has been no consideration of the topography.

Slope and aspect of the land surface are other important considerations to raise when planning for recreation land use. Figures 12 and 13 show the elevation and topography within the open space, from which we can derive slope and aspect of the area. The slope of the open space ranged from 0 to 60 degrees. To simplify analysis, groupings of slope angle were created: 0-5 was low angle, 5-15 medium angle, and slopes above 15 degrees was considered high angle. The aspect data were grouped into eight cardinal directions.

Trail slope is critical when evaluating where to place trails. The natural incline of the land must not become an adversary to the resource. It may be impossible to avoid steep slopes all the time, but when they are identified, planners can make adjustments to ensure minimal impact. In the case of Monument Open Space, areas with steep slopes can be easily identified and then evaluated for disproportionate erosion. Aspect is also important to consider modeling for erosion or ecological impact due to the high vegetation differential on north vs. south facing slopes.

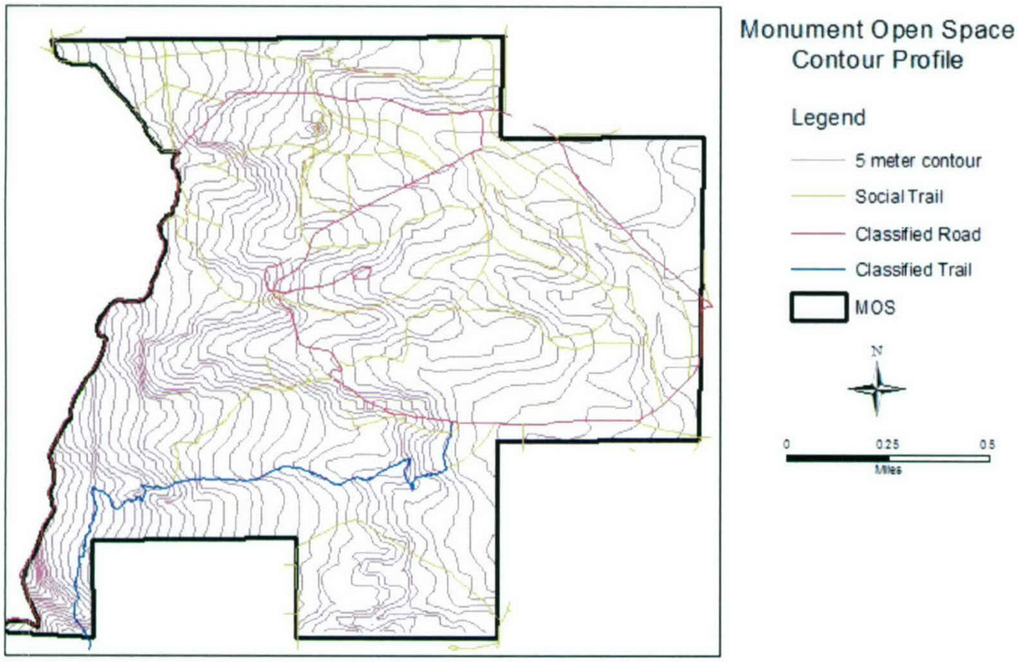

Figure. 12 Five meter contour profile

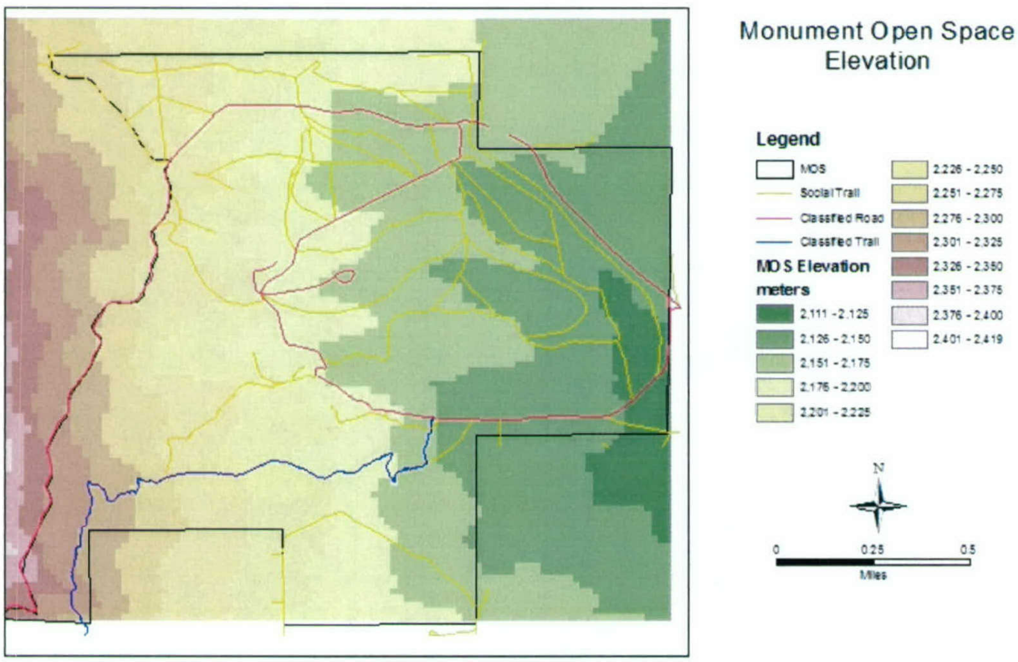

Figure. 13 Elevation of Monument Open Space

Figure 14 shows the intersection of trails and slopes of greater than 15 degrees. These locations alone are candidates for elimination. When correlated with sensitive aspect locations and previously identified sensitive areas planners can propose elimination or at the very lease monitor these specific locations and develop control measures to reduce trail impacts.

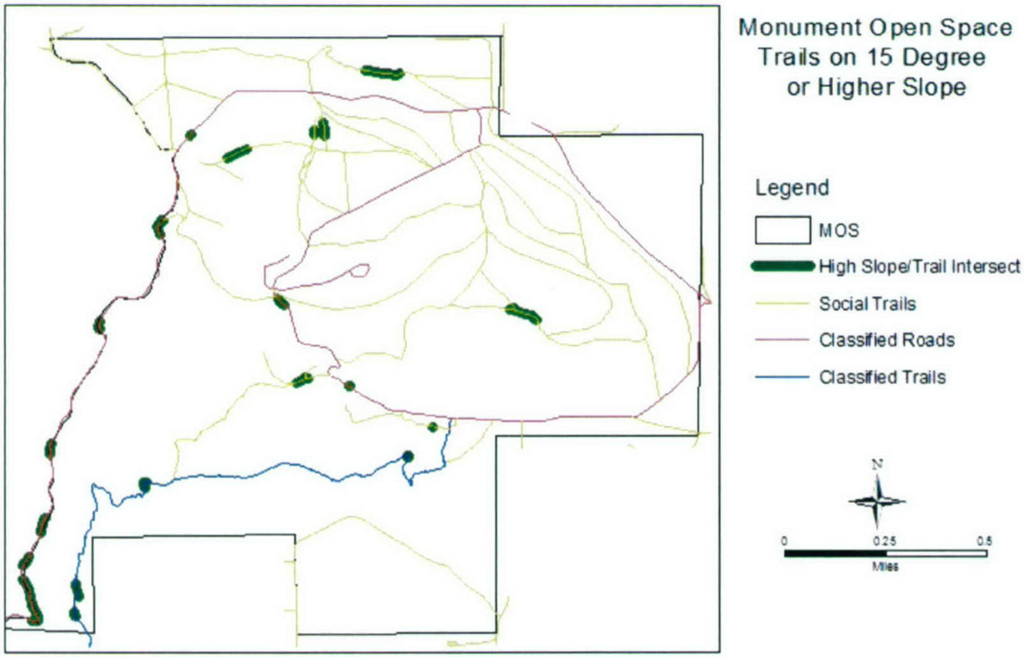

Figure. 14 Trails with a slope over 15 degrees

Given the historical context of the open space it is also important to record the cultural features located within this space (Figure 15). The buildings identified are historical and have been restored and renovated to support the wildland firefighters who are stationed there.

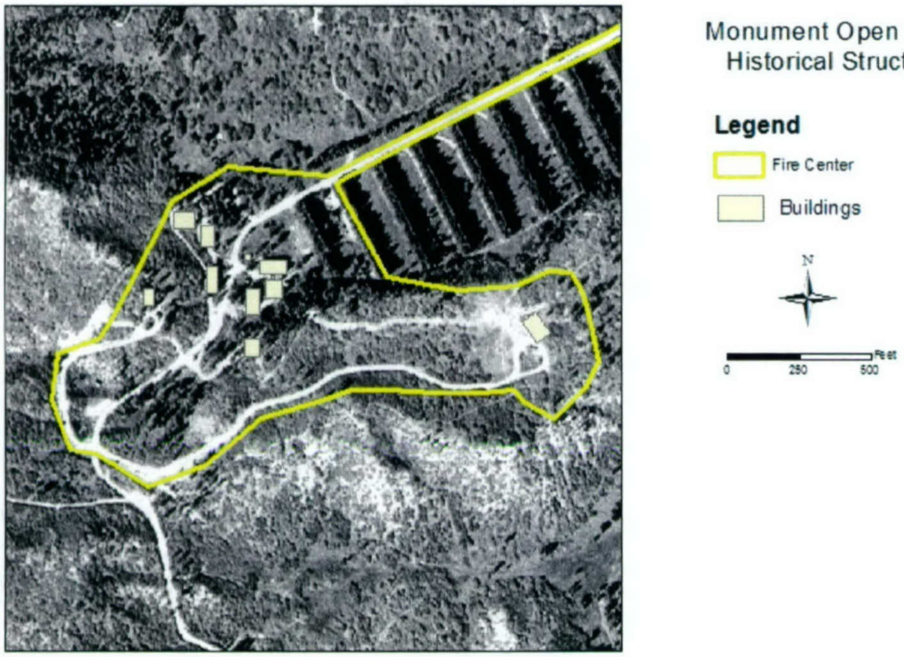

Figure 15 Historical Structures

In addition to the existing structures, there are several archeological sites within the open space, but those were not included due to their sensitive nature and the desire of the Forest Service to not make the data public at this time. Thus, maps and features of sensitive layers should be retained by the land managers and used for internal planning decisions. However, in the future there is a goal that historical and cultural markers be placed to highlight the history of the open space and maps of cultural artifacts would be perfect to use in planning the location of those markers.

In working to restore and preserve these structures, assessment of the hazards that are present is important, especially for wildfires. Using historical fire points along with slope and aspect data, a fire potential map can be made. Previous fire points in the open space have occurred mostly on moderately sloping ground with an east aspect. Figure 16 clearly shows that the Monument Fire Center administrative area, containing a hotshot

and heliattack crew, also has matching slope and aspect conditions. Slope and aspect are just initial factors to consider when evaluating fire potential. Other factors include available fuel for a fire and building construction. From this map fire mitigation efforts could be planned to preserve cultural features inside of the Fire Center.

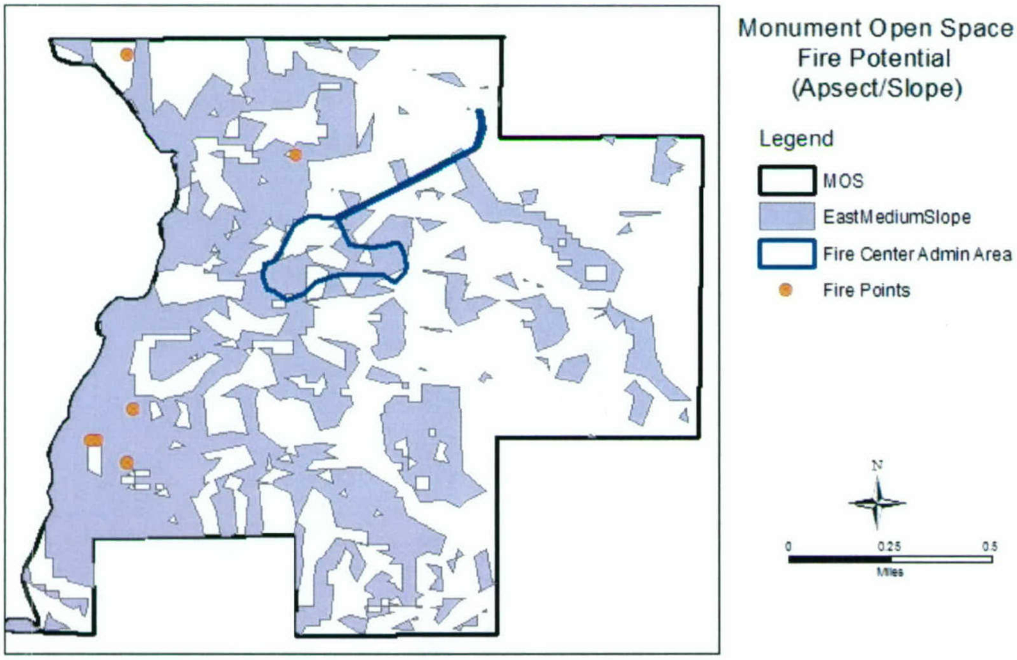

Figure 16, Fire potential based on aspect and slope

The last goal listed in the implementation plan not yet analyzed is locating 3 trailheads and 2-3campsites within the open space. These locations would be close to the road. A 25 meter buffer around classified roads was created to allow for parking and turnaround. The buffered road layer was then intersected with a layer representing slopes of less than five degrees (Figure 17). Locations in these areas near trail intersections would be candidates for trailhead parking. Sites in these areas farther from trail

intersections could be used as campsites. Other variables can be examined on the ground in these candidate areas to determine the most suitable location.

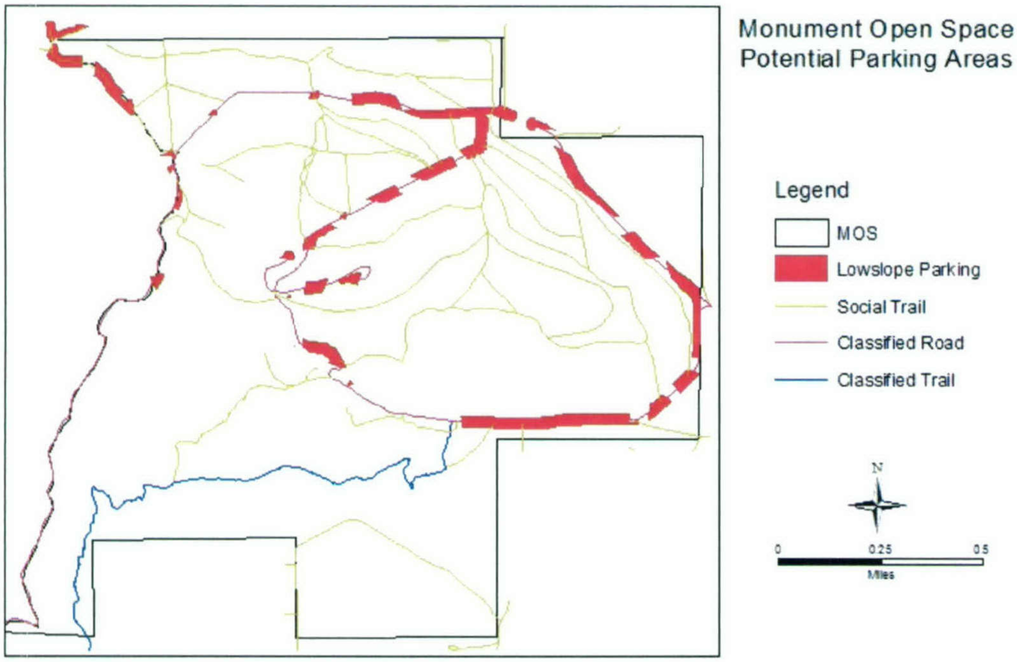

Figure17. Potential parking and camping areas

The second element of this analysis is the incorporation of satellite imagery in assisting planning decisions. Applied to the Limits of Acceptable Change method satellite imagery can be used to monitor and highlight areas of change or to determine the nature of change once the resource and cultural standards are established. An added benefit of satellite imagery is that multi-spectral images can highlight features such as newly exposed soil or unusual vegetation patterns that would normally be invisible in typical photos or images.

Satellite imagery for this thesis was collected from the National Geospatial Agency where they store satellite imagery for government agencies. Although not the

highest spatial resolution when compared to other satellites, Landsat 5 was used to perform a change detection procedure to demonstrate general capabilities of image processing. Landsat 5 was the only platform to have imagery covering the open space and surrounding area on two separate years that was collected.

Change detection analysis allows users to create an image using spectral layers from two different data sets. This analysis allows the user to easily see what has changed from the earlier date to the more recent. One problem encountered was that Landsat 5 has a resolution of 30 meters. Change detection over the Monument Open Space at this resolution did not produce any results. In order to show this capability, I did a change detection analysis to the east of the open space where significant development occured and would be detectable at 30 meter resolution (Figure 18). Figures 18 a and 18 b are true color multi-spectral composite images containing the blue, green and red bands. Figure 18c is a composite image using the 1998 blue band combined with the green and red bands from 1997. The result shows that the bright blue areas represent changes between the two imagery dates.

Fig. 18a 1997 True color, Landsat-5

Fig. 18b 1998 True color, Landsat-5

Fig. 18c Change Detection between 1997 and 1998, Landsat-5

Other platforms, such as IKONOS or Quickbird, do have multi-spectral capabilities and resolutions of 1meter or less. With the higher resolution it may be possible to track changes in trail routes over time, check to see how well restoration is going, or see if any new trails are developing.

From the examples shown it is not suggested that spatial analysis possibilities have been exhausted. The potential for additional and further refined spatial analysis is nearly limitless. This case study only provided a small example of what geographic technologies can provide when incorporated into planning methods. The Limits of

Acceptable Change method provides several avenues for GIS and IP to be incorporated because the focus is on assessing current resource and social conditions, establishing limits of change, and then modeling and implementing the best possible solution to maintain acceptable resource and social conditions. The other models mentioned also have several opportunities to introduce geographic technology, however, due to various foci of those methods, the application of GIS and IP would have a different emphasis.

Whatever the method or application, thoughtfully created graphics showing the results of analysis can go a long way in explaining to the public a recreation plan and the considerations behind the plan. These graphics also provide stakeholders the tools they need to also contribute to planning decisions. Without these graphics achieving a consensus will be difficult if not unlikely.

GIS and its spatial analysis capability along with the tracking capability of Image Processing are great tools to have in developing recreational land use plans as well as maintaining the plan over the course of its lifespan.

CHAPTER IV

RESULTS AND DISCUSSION

In the Monument Open Space, local users want to keep all existing trails, but the Forest Service would like to eliminate trails to bring the open space into compliance with trail density standards. One last map offers a potential of what the travel route network could look like if trails were eliminated based upon repeated selection as provided in the examples (Figure 19). While this map does not fully bring the trail density down to ten miles of trial per square mile of recreation area as estimated, it eliminates approximately 7 miles of trail and it is a start in the right direction.

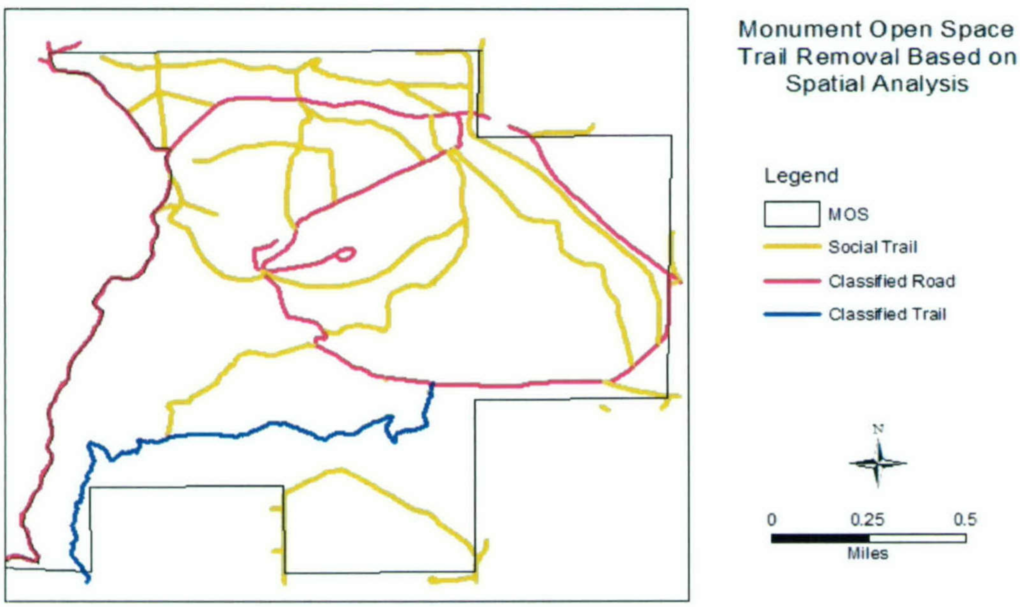

Fig. 19 Trail removal based on spatial analysis selections

As you can see, several trails have been eliminated specifically in the top center and just to the right of center in this map. Working with different user groups consensus solutions can be achieved without various user groups feeling cheated of recreation opportunity (Gobster 2001).

This proposed change also influences the potential parking and camping area selection shown in figure 17. This highlights the fact that planning is complicated, and everything is interconnected. In addition to analyzing site selection of parking and camping potential, different user groups should also be considered. Equestrian users will, generally, have to trailer their horses to the open space, which means that they may need a larger area to maneuver their truck and trailer in. An additional consideration for equestrian users is to locate their parking area away from the main traffic route so other users do not scare the horses.

The maps and imagery analysis possibilities of this project are very promising. The results from both GIS and Image processing applications show strong potential for application when developing a plan and discussing proposals to stakeholders. Maps have a curious ability to draw attention, stimulate thought and discussion, and ultimately lead stakeholders and planners to solutions that reflect the least amount of impact on the resource. The goal is to maximize enjoyment of users while limiting conflict all at the same time.

Given the variety of methodologies for planning recreational land uses that lack GIS and IP technology, it is hard to understand why the connection between the two has not been fully realized and implemented in a recreation context. The spatial analysis

conducted in this case study shows that there is a clear relevance and application for incorporating geographic technology into planning processes.

Some may argue that there is a sizable expense to incorporating these data sets. That is not the case-data are easy to obtain and/or create, and much is free via Internet geography networks. Satellite imagery may be a little more difficult to obtain due to potential costs of requesting specific data, however, government agencies should be able to request and acquire the highest quality imagery to facilitate their needs. There is a strong presence of GIS usage at all levels of government, so the issue is not one of access and cost of software, the issue in this case is the targeted application and allocation of time and energy to the task of creating maps and products that will assist planners and stakeholders in recreational land use decisions.

When considering the cost for the salary of a GIS/IP technician compared to costs of litigation due to conflicts resulting from planning without using these technologies, it is more cost effective and productive to hire or subcontract a GIS/IP technician. While costs and planning efforts are related, they are not the focus of this thesis. The focus is to show that these technologies exist and that they can be easily incorporated into comprehensive recreation planning methodologies, producing maps that facilitate clearer understanding of the logic, constraints, and policy decisions that go into creating a land management plan.

These technologies must also be included when public comments are solicited. By allowing stakeholders to observe maps containing planning considerations earlier and asking for their input can often identify additional considerations, test for support of the plan, and even result in significant changes based on user preferences without greater

impact on the resource. As stated earlier, if the stakeholders support the plan it will be easier for recreation land managers to implement the final plan and have users follow its guidance.

Monument Open Space is an excellent example of an existing area that needs the assistance of planning and implementing a comprehensive recreation use plan. The maps and products created above can go a long way towards creating consensus between the stakeholders and land managers. In essence, it is imperative that land managers incorporate and use geographic technologies in planning and maintaining the recreational resources under their control. Likewise, it is important to expand this work to look at regional applications in order for the local managers to make decisions that support the regional objectives.

Improvements upon the GIS portion of this study would include obtaining more detailed base layers, and an orthophoto or similar image with a resolution smaller than one meter to use as a base for digitizing or overlaying subsequent data layers. Additionally, using a GPS unit that can precisely record point, line, and polygon data would also be a great benefit. This would be particularly valuable when creating and updating the archeological and cultural data layers or any other special features.

The Image Processing aspect of this study can also be improved; another application of multispectral imagery is the capability to conduct a supervised ground cover classification. By using high-resolution data, 1meter or less, users can create products that can accurately reflect the true ground cover in an area. This would give planners and users better ideas of the extent that trail and use patterns are affecting different vegetation types. One possible application of a supervised classification would

be to identify the noxious weed colonies and then see how extensive the problem is within the open space and how fast the weeds are spreading. The latter portion would incorporate a change detection type procedure as shown above.

The short and long term impacts of collecting and using data cannot be fully evaluated. However, the immediate benefits could be quite extensive: improved communication and relationships between planners and users, reduced conflicts among different user groups, and identification of conflicts between user and resource all because some time was taken to utilize and incorporate geographic technologies into planning and sustainment methodologies.

CHAPTER VII

CONCLUSION

Evaluating the process of recreational land use management has made it clear that planning methods are very complex and take a significant amount of time to complete and implement. Likewise, it is also clear that incorporating GIS and Image Processing technologies into the planning process will eliminate shortfalls within the planning methods, increase their effectiveness, and be valuable tools when working with stakeholders to receive input and to explain planning constraints.

With the quality of geographic data available today it is imperative that planners embrace available geographic technology to help facilitate planning and shorten the time required to execute a management plan. By using these tools and significant public involvement throughout the whole process the resulting plan can also be executed and maintained easier by both the land management agency and stakeholders.

Future research should include advancing this topic onto a regional level in order to view user group distribution so local efforts complement regional objectives. Additionally, it would be interesting to look into changes in user group perceptions and interactions over the course of the planning process in order to gain additional insight to reduce conflict and accelerate plan execution.

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